GLOBALSTAR, L.P.

RESPONSE TO FCC PUBLIC NOTICE DA 02-554
TECHNICAL COMMENTS ON CERTAIN PROPOSALS TO PERMIT FLEXIBILITY IN THE DELIVERY OF COMMUNICATIONS BY MOBILE SATELLITE SERVICE PROVIDERS IN L-BAND, THE 2 GHz BAND AND THE 1.6/2.4 GHz BANDS

In its Public Notice, the Commission invited technical comments on whether the operations of mobile satellite services (MSS) in the 2 GHz band, L-Band and the “Big LEO” bands (MSS Bands) can be “severed” from terrestrial operations in each band. Globalstar demonstrates in the following analysis that it is not possible to “sever” satellite and terrestrial operations.

The successful operation of an Ancillary Terrestrial Component (ATC) of a mobile satellite service system will be dependent upon the ability of the operator to manage the use of spectrum on a dynamic, minute-by-minute basis. Lack of this ability will lead to disruptive levels of interference to both the satellite and terrestrial components and preclude efficient spectrum usage.

This analysis first examines interference between the ATC and the satellite component. Coordination of frequency sharing between the ATC and satellite components of an integrated system controlled by the MSS operator is discussed next. Then, interference to services co-frequency and in adjacent bands is discussed, including radio astronomy, mobile satellite, radionavigation satellite, multipoint multichannel distribution and instructional television. Finally, comments on the applicability of Part 24 rules to ATC are provided.

Although the following analysis addresses only the 1.6/2.4 GHz bands in which Globalstar is currently operating, the techniques used and conclusions reached are equally applicable to the 2 GHz MSS bands.

1.0 Interference between the Ancillary Terrestrial and Satellite Components

In this section, interference from ATC into MSS and from MSS into ATC is investigated. The case of ATC into MSS is treated first.

Interference from ATC into MSS

1.1.1 Interference Mechanisms

For this paper it is assumed that the ATC will be operating in the existing bands that Globalstar uses. The frequency allocations for Above 1 GHz MSS systems are at:

Earth-to-space	space-to-Earth
1610 – 1626.5 MHz	2483.5 – 2500 MHz.

The band 1613.8 – 1626.5 MHz may also be used in the space-to-Earth direction on a secondary basis.

For this analysis, it is assumed that, in an ATC situation, all of the frequencies would be used by both the ATC and the MSS systems. However, the analysis is limited to CDMA MSS systems. Interference into an MSS system from the ATC component can occur as illustrated in the following table.

TABLE 1-1
Interference Mechanisms for ATC Interference into an MSS System

Interfering Transmitter	Victim Receiver
ATC Base Station Transmitter	MSS Terminal Receiver
ATC Base Station Transmitter	MSS Spacecraft Receiver
ATC Terminal Transmitter	MSS Terminal Receiver
ATC Terminal Transmitter	MSS Spacecraft Receiver

1.1.2 Potential Interference Levels

In order to determine the potential interference into an MSS system from ATC, it is necessary to assume certain system characteristics. The following tables show the assumed characteristics of the ATC mobile and base stations. For this study, the ATC is assumed to use cdma2000. These terrestrial station characteristics are taken from FCC Final Staff Report, *Spectrum Study of the 2500-2690 MHz Band-The Potential for Accommodating Third Generation Mobile Systems*, 30 March 2001.

Table 1-2
ATC System Characteristics
(cdma2000)

Parameter	Mobile	Base Station
Carrier Spacing	1.25 MHz	1.25 MHz
Transmitter Power	0.1 W	10 W
Antenna Gain	0 dBi	17 dBi
Antenna Height	1.5 m	40 m
Body Loss	0 dB	------------
Tilt of Antenna	------------	-2.5 degs
Access Technique	CDMA	CDMA
Data Rate Supported	153.6 kbps	153.6 kbps
Modulation Type	QPSK/BPSK	QPSK/BPSK
Receiver Noise Figure	9 dB	5 dB
Receiver Thermal Noise Level In Bandwidth = Data Rate In Receiver Bandwidth	 -155 dBW -134 dBW	 -147 dBW -138 dBW
Eb/No	4.0 dB for 1% FER	6.0 dB for 0.3% FER
Receiver Sensitivity	-134 dBW for 1% FER	-149 dBW for 0.3% FER
Interference Threshold (Desired Signal @ Sensitivity, I/N=-6 dB and 10% loss in Range)	-140 dBW	-144 dBW
Interference Threshold (Desired Signal @ Receiver Sensitivity = +10 dB, S/(I+N) for a BER of 10^{-3})	-124 dBW	-128 dBW

In previous analyses the threshold of unacceptable interference for a Globalstar mobile terminal has been stated as –100 dBm at the receiver antenna output. This value is based on analysis in the Technical Appendix to the Comments of Loral/Qualcomm Partnership submitted during the “Big LEO” Rulemaking (CC Dkt. 92-166). The analysis indicated that call disruption would occur for a received signal level (RSL) of –90 dBm, at the output of the handset antenna, and degradation would occur for a RSL of –95 dBm.

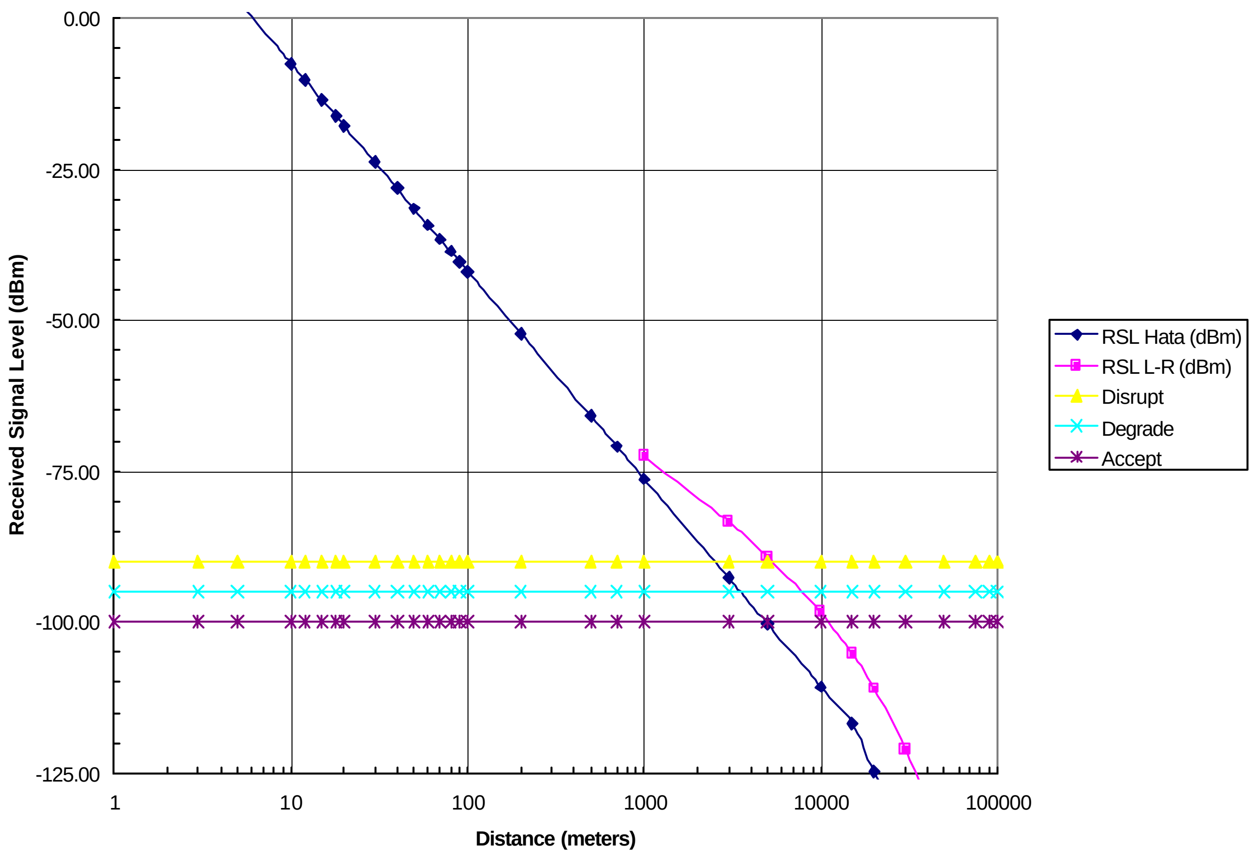
The threshold for unacceptable interference at the spacecraft receiver has been taken as an increase in the spacecraft receive noise temperature, assumed to be 500 K, of 6%. This is equivalent to an Interference-to-Noise ratio (I/N) of –12.2 dB. This increase in noise temperature corresponds to an interference density of –213.8 dBW/Hz. Using these thresholds the interference potential for each of the cases shown in Table 1-1 can be calculated.

1.1.3 Base Station Transmitter into MSS Terminal Receiver

An ATC base station transmitter operating on the same frequency as an MSS terminal receiver would represent a significant source of interference for the MSS terminal. By their very nature, MSS terminals typically operate at much lower receive levels than do terrestrial cellular receivers. Terrestrial receive levels could approach those of MSS terminals when the terrestrial receiver was operating deep inside a building. Since terrestrial systems are designed to provide service inside buildings, their base station transmitters must operate at rather high power levels.

Figure 1.3 illustrates the received interference level from a terrestrial base station transmitter as a function of separation distance. For this interference case, the received level from the terrestrial base station was calculated using the Hata model which is given in ITU-R Recommendation P.529-3 and the Longley-Rice model from NTIA. The Hata model is recognized as depicting typical propagation loss for terrestrial cellular systems in dense urban areas while the Longley-Rice model is referenced in the FCC Rules for calculating the coverage of PCS systems. Note that, according to the Hata model, the MSS terminal must be 5 kilometers away from the terrestrial base station before the interference is at an acceptable level while the Longley-Rice model indicates that the MSS terminal must be 10 kilometers from the ATC base station before interference is at an acceptable level.

Figure 1-3
Received Signal Level at MSS Terminal from ATC Base Station as a Function of Distance from Base Station



1.1.4 <u>Base Station Transmitter into Spacecraft Receiver</u>

If a terrestrial base station transmitter is operating on the same frequency as an MSS spacecraft receiver, unacceptable interference will be received when the spacecraft is at certain ranges and attitudes with respect to the terrestrial base station. This represents a "reverse band" usage of the MSS frequencies by the ATC. The ATC handset would be receiving in the MSS uplink band.

ATC base station antennas would be placed in relatively high locations in order to optimize coverage to ATC terminals. As a consequence, the base station antennas would likely have unobstructed or nearly unobstructed paths to the spacecraft receiver. The majority of the power from the base station antenna would be directed downward at angles below the horizon, but sidelobes of the base station antenna pattern would allow some power to be directed above the horizon and towards the spacecraft. A preliminary estimate of the interference from ATC base stations can be made by assuming that the base station antenna is isotropic (0 dB gain) and that the average gain of the spacecraft is 15 dB.

The threshold of acceptable interference is assumed to be –213.8 dBW/Hz based upon a $\Delta T/T$ of 6%. This is a threshold for GSO FSS systems but is assumed here as a typical interference threshold. A terrestrial base station would produce an EIRP density of –50.4 dBW/Hz. Assuming the range to the spacecraft to be 4481 kilometers and free space loss between the ATC base station and the Globalstar spacecraft, the resulting interference is calculated as follows:

$$I\ (\mathrm{dBW/Hz}) = P_{ATCBS} - FSL + G_{S/C} = -50.4 - 169.6 + 15.0$$
$$= -205.0\ \mathrm{dBW/Hz}$$

where: P_{ATCBS} is the EIRP density of the ATC base station transmitter in dBW/Hz

FSL is the free space loss in dB

$G_{S/C}$ is the gain of the spacecraft L-Band antenna in dB.

The interference from one ATC base station is 8.8 dB greater than the threshold. Multiple base stations within view of the spacecraft would increase the interference by 10 log of the number of base stations.

1.1.5 ATC Terminal Transmitter into MSS Terminal Receiver

For a terrestrial terminal transmitter operating on the same frequency as an MSS terminal receiver, significant interference will be received by the MSS terminal if the two terminals are close enough to each other. Cellular transmitters typically have lower power output as compared with satellite terminal transmitters. The power of a cellular terminal can increase if power control is being used by the cellular system. This represents a “reverse band” usage of the MSS frequencies. The ATC handset would be transmitting in the MSS handset receive (downlink) band.

Figure 1-4
Received Signal Level at MSS Terminal from ATC Handset as a Function of Distance from the Handset

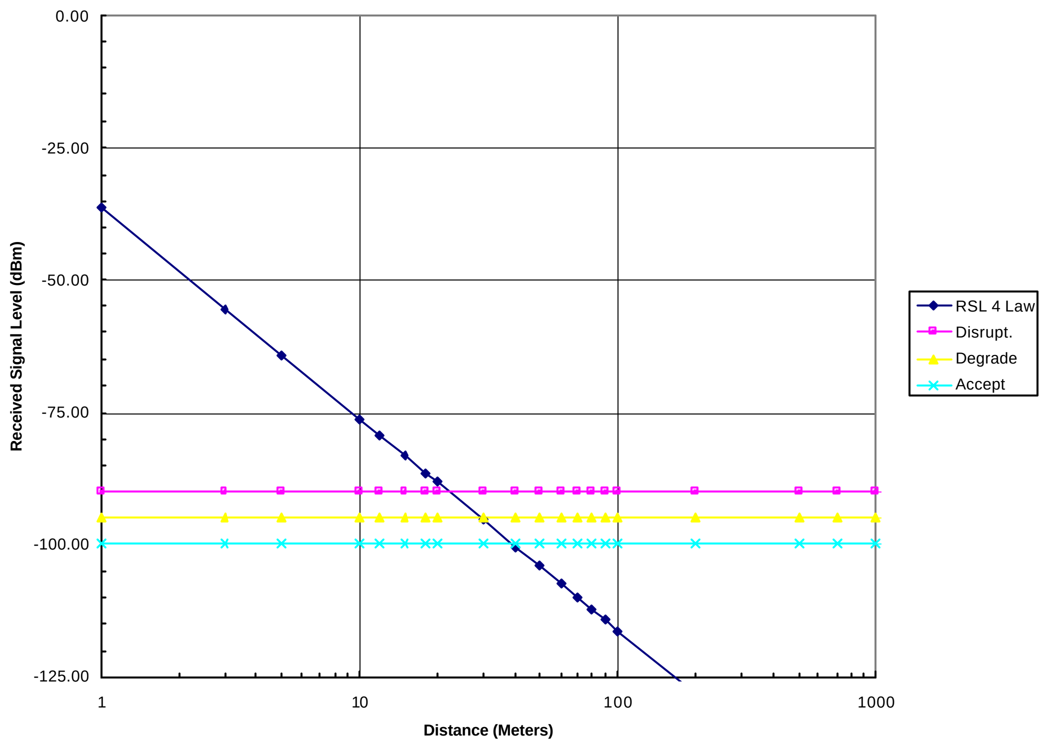


Figure 1.4 shows the interference received by a satellite component terminal when the same frequencies are used for ATC. It is assumed that the ATC terminal and satellite component terminal are not within “line-of-sight” of each other. A fourth power propagation loss is assumed to take into account obstacles and multi-path that could exist between the two terminals. Under these assumptions, unacceptable interference will occur when the two terminals are within 40 meters of each other.

1.1.6 ATC Terminal Transmitter into Spacecraft Receiver

Since the terminals of the terrestrial system and the MSS system operate in a similar manner, except for differences in transmit power, the aggregation of power from a number of terrestrial terminals could cause unacceptable interference to the MSS spacecraft receiver.

The threshold of acceptable interference is assumed to be –213.8 dBW/Hz based upon a $\Delta T/T$ of 6%. This is a threshold for GSO FSS systems but is assumed here as a typical interference threshold. It represents a degradation in Eb/No of 0.25 dB. A terrestrial handset transmitter would produce an EIRP density of

–70.4 dBW/Hz. Assuming the range to the spacecraft to be 1414 kilometers and free space loss between the ATC terminal and the Globalstar spacecraft, the resulting interference is calculated as follows:

$$I\ (dBW/Hz) = P_{ATC} - FSL + G_{S/C} = -70.4 - 159.6 + 14.7$$

$$= -215.3\ dBW/Hz$$

where: P_{ATC} is the EIRP density of the ATC handset transmitter in dBW/Hz

FSL is the free space loss in dB

$G_{S/C}$ is the gain of the spacecraft L-Band antenna in dB.

The threshold is only 1.4 dB greater than the interference produced by one ATC handset, thus, two handsets would violate this threshold. It is noted that the above interference calculation represents a worst case scenario. Polarization losses were not taken into account (2 to 3 dB), the satellite is directly overhead, and it is assumed that there are no losses other than free space loss between the ATC terminal and the Globalstar spacecraft. The range between the handset and the spacecraft would vary as a function of look angle from the spacecraft as would the gain of the spacecraft antenna. The overall loss, due to the maximum range (4481 km) to the spacecraft combined with the antenna gain, results in a decrease of the interference to -223.1 dBW/Hz. Assuming the optimistic interference case, where all of the interfering handsets would be at the maximum range, the interference from nine ATC handsets would exceed the threshold.

The average propagation loss between the terrestrial handsets and the spacecraft receiver will likely be greater than free space loss due to shadowing and multi-path effects. These effects have stochastic characteristics. A complete characterization of these effects is beyond the scope of this short analysis. A pessimistic estimate of the average loss due to these effects is 15 dB, a factor of 30. When this 15 dB is combined with free space loss, the resulting number of terrestrial terminals required to violate the interference threshold will be between 30 and 270 depending upon the range of the terminals to the spacecraft. Terrestrial terminals operating in the open or as vehicular units would likely cause more interference than a greater number of handheld units in a typical operating environment.

1.1.7 Summary of ATC Interference into MSS

This analysis has examined the issue of sharing frequencies between the MSS component and ATC. Four interference cases, shown in Table 1-1, were examined, two using frequencies in the same “direction” as the MSS systems and two where the ATC was using frequencies in the “reverse direction.” ATC use of the MSS frequencies in the forward direction results in interference from ATC terminals into the MSS spacecraft receiver and interference from the ATC base station into the MSS handsets. ATC “reverse band” use of the MSS frequencies results in interference from the ATC base station into the MSS spacecraft receiver and from the ATC terminal into the MSS terminal.

The least problematic interference situation is the ATC handset interfering with the MSS handset. The analysis shows that terminals could be within 40 meters of each other and operate successfully.

More severe is the interference from ATC handsets into the MSS spacecraft receiver. The analysis indicates that, preliminarily, tens of ATC handsets could produce unacceptable interference to the MSS spacecraft.

Even more severe is the interference from ATC base stations into MSS handsets. The analysis shows that unacceptable interference will occur to an MSS handset when it is within 5 km of an ATC base station.

Most severe is the interference from an ATC base station into an MSS spacecraft. One ATC base station within view of an MSS spacecraft will exceed the acceptable interference threshold by a factor of 7.5.

Based on the above, ”reverse band” usage of the MSS frequencies by the ATC would result in the most severe interference with “forward band” ATC usage resulting in less interference. The interference caused by ATC to MSS operations by severing satellite and terrestrial operations would be unacceptable in either case.

1.2 Interference from ATC Using IS-95 Technology into MSS

This section studies the effect of interference from ATC into MSS when the ATC system uses IS-95 technology. In order to determine the potential interference into an MSS system from an ATC it is necessary to assume certain system characteristics. The following tables show the characteristics of the ATC mobile and base stations. For this study, the ATC is assumed to use IS 95A. The methodology used for the analysis is same as that for cdma2000 ATC interference analysis.

Table 1-5
ATC System Characteristics
(IS 95)

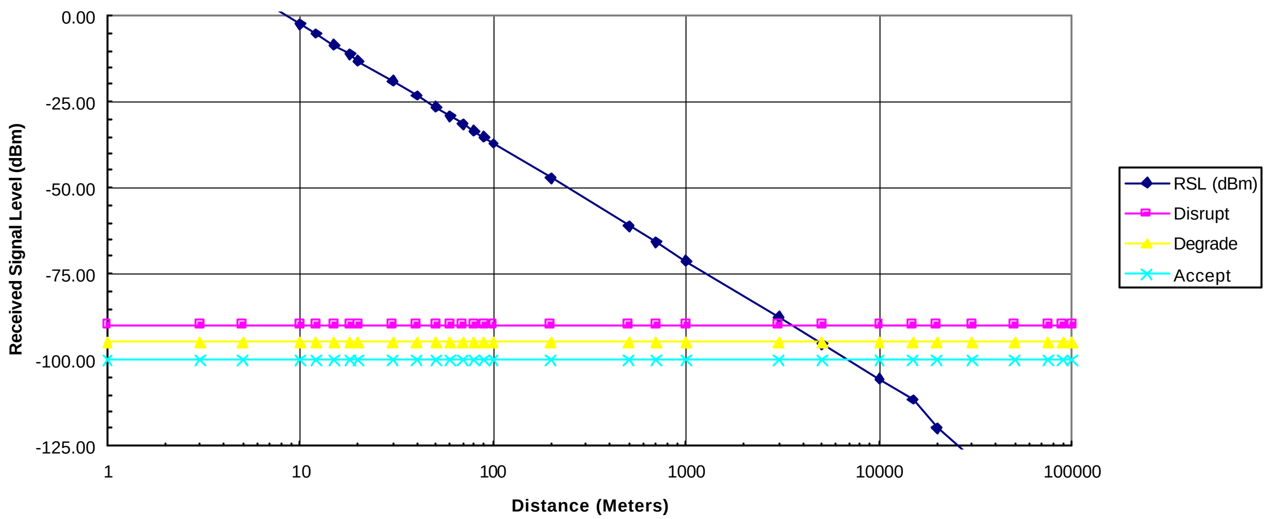
Parameter	Mobile	Base Station
Carrier Spacing	1.23 MHz	1.23 MHz
Transmitter Power	0.2 – 1.0 W (Class III)	20 W
Antenna Gain	0 dBi	19 dBi
Antenna Height	1.5 m	40 m
Body Loss	0 dB	--------------
Tilt of Antenna	------------	-2.5 degs
Access Technique	CDMA	CDMA
Data Rate Supported	9.6 kbps	9.6 kbps
Modulation Type	QPSK	QPSK
Out-of-Channel EIRP >900 kHz offset from center >1.98 MHz offset from center	 -42 dBc/30kHz -54 dBc/30kHz	 -45 dBc/30kHz (>750 kHz from center) -60 dBc/30kHz
Receiver Noise Figure	5-8 dB	5 dB
Receiver Thermal Noise level In Receiver bandwidth	-102.9 dBm	-100.3 dBm
Eb/No for Pe = 1% FER	4.3 dB	4.32 dB
Receiver Sensitivity @ 1% FER	-104 dBm	-117 dBm
Interference Threshold (Desired Signal @ Sensitivity, I/N=-6 dB)	-108.9 dBm	-106.3 dBm
Interference Threshold (Desired Signal @ Signal 10 dB above Sensitivity, S/(I+N) 1% FER)	-93.4 dBm	-90.8 dBm

1.2.1 Base Station Transmitter into MSS Terminal Receiver

Figure 1.6 illustrates the received interference level at an MSS terminal from a terrestrial IS-95 base station transmitter as a function of separation distance. Note that the

MSS terminal must be 7 kilometers away from the terrestrial base station before the interference is at an acceptable level. For this interference case, the received level from the terrestrial base station is calculated using the Hata model given in ITU-R Recommendation P.529-3. This model is recognized as depicting typical propagation loss for terrestrial cellular systems in dense urban areas.

Figure 1-6
Received Signal Level at MSS Terminal from ATC Base Station Transmitter as a Function of Distance from the Base Station



1.2.2 Base Station Transmitter into Spacecraft Receiver

The threshold of acceptable interference is assumed to be –213.8 dBW/Hz based upon a $\Delta T/T$ of 6%. A terrestrial base station would produce an EIRP density of –47.4 dBW/Hz. Assuming the range to the spacecraft to be 4481 kilometers and free space loss between the ATC base station and the Globalstar spacecraft, the resulting interference is calculated as follows:

$$I\ (\text{dBW/Hz}) = P_{ATCBS} - FSL + G_{S/C} = -47.4 - 169.6 + 15.0$$

$$= -208.0\ \text{dBW/Hz}$$

where: P_{ATCBS} is the EIRP density of the ATC base station transmitter in dBW/Hz

FSL is the free space loss in dB

$G_{S/C}$ is the gain of the spacecraft L-Band antenna in dB.

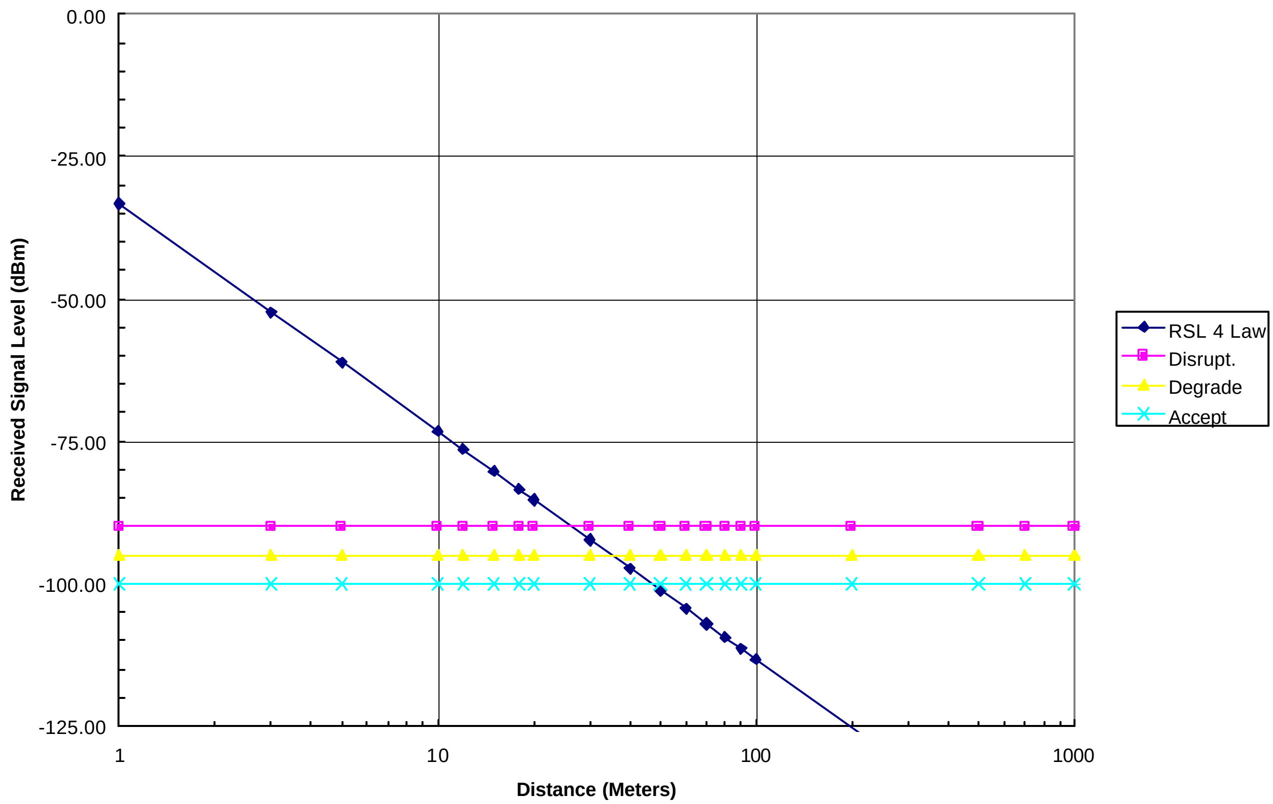
The interference from one base station is 5.8 dB greater than the threshold. Multiple base stations within view of the spacecraft would increase the interference by 10 log of the number of base stations.

1.2.3 ATC Terminal Transmitter into MSS Terminal Receiver

For a terrestrial IS-95 terminal transmitter operating on the same frequency as an MSS terminal receiver, significant interference will be received by the MSS terminal if the two terminals are close enough to each other. Cellular transmitters typically have lower power output as compared with satellite terminal transmitters. The power of a cellular terminal can increase if power control is being used by the cellular system. This represents a “reverse band” usage of the MSS frequencies. The ATC handset would be transmitting in the MSS handset receive band (S-band).

Figure 1.7 shows the interference received by a satellite component terminal when the same frequencies are used for ATC. It is assumed that the ATC terminal and satellite component terminal are not within “line-of-sight” of each other. A fourth power propagation loss is assumed to take into account obstacles and multi-path that could exist between the two terminals. Under these assumptions, unacceptable interference will occur when the two terminals are within 50 meters of each other. This is the minimum separation distance required for IS-95 class III terminal. In presence of power control, the ATC terminal will transmit higher power and the separation distance will increase. Class I and Class II IS-95 terminals will require greater separation distance.

Figure 1-7
Received Signal Level at MSS Terminal from ATC Handset as a Function of Distance from the Handset



1.2.4 <u>ATC Terminal Transmitter into Spacecraft Receiver</u>

Since the terminals of the terrestrial system and the MSS system operate in a similar manner, except for differences in transmit power, the aggregation of power from a number of terrestrial terminals could cause unacceptable interference to the MSS spacecraft receiver.

The threshold of acceptable interference is assumed to be –213.8 dBW/Hz based upon a $\Delta T/T$ of 6%. It represents a degradation in Eb/No of 0.25 dB. A terrestrial handset transmitter would produce an EIRP density of –67.4 dBW/Hz at the minimum. Assuming the range to the spacecraft to be 1414 kilometers and free space loss between the ATC terminal and the Globalstar spacecraft, the resulting interference is calculated as follows:

$$I\ (\text{dBW/Hz}) = P_{ATC} - FSL + G_{S/C} = -67.4 - 159.6 + 14.7$$

$$= -212.3\ \text{dBW/Hz}$$

where: P_{ATC} is the EIRP density of the ATC handset transmitter in dBW/Hz

FSL is the free space loss in dB

$G_{S/C}$ is the gain of the spacecraft L-Band antenna in dB.

This shows that one ATC handset will violate the threshold. It is noted that the above interference calculation represents a worst case scenario. Polarization losses were not taken into account (2 to 3 dB), the satellite is directly overhead, and it is assumed that there are no losses other than free space loss between the ATC terminal and the Globalstar spacecraft. The range between the handset and the spacecraft would vary as a function of look angle from the spacecraft as would the gain of the spacecraft antenna. The overall loss, due to the maximum range (4481 km) to the spacecraft combined with the antenna gain, results in a decrease of the interference to –220.1 dBW/Hz. Assuming the optimistic interference case, where all of the interfering handsets would be at the maximum range, the interference from five ATC handsets would exceed the threshold.

The average propagation loss between the terrestrial handsets and the spacecraft receiver will likely be greater than free space loss due to shadowing and multi-path effects. These effects have stochastic characteristics. A complete characterization of these effects is beyond the scope of this short analysis. A pessimistic estimate of the average loss due to these effects is 15 dB, a factor of 30. When this 15 dB is combined with free space loss, the resulting number of terrestrial terminals required to violate the interference threshold will be between 22 and 135 depending upon the range of the terminals to the spacecraft. Terrestrial terminals operating in the open or as vehicular units would likely cause more interference than a greater number of handheld units.

1.2.5 Summary of Interference from ATC using IS-95 into MSS

The following table summarizes the results of the interference analysis performed to consider frequency sharing between MSS and ATC components using IS-95 air interface. The table also compares the performance of IS 95 and cdma2000 ATC components. As seen from the table, IS 95 components will cause greater interference into MSS while sharing the same frequency.

Table 1-8
Comparison of Effects of Interference into MSS from ATC Using cdma2000 and IS-95

	cdma2000	**IS 95A**
Base Station Transmitter into MSS Terminal Receiver	Separation distance is 5 km	Separation distance is 7 km
Base Station Transmitter into Spacecraft Receiver	Interference threshold is 8.8 dB higher. 7-8 base stations will violate.	Interference threshold is 5.8 dB higher. 3-4 base stations will violate.
ATC Terminal Transmitter into MSS Terminal Receiver	Separation distance is 40 m	Separation distance is 50 m
ATC Terminal Transmitter into Spacecraft Receiver	2 ATC handsets violate the threshold. With 15 dB fading loss, 30-270 handsets can be supported	1 ATC handset violates the threshold. With 15 dB fading loss, 22-135 handsets can be supported

Interference from MSS into ATC

This section considers the interference from MSS into ATC for the forward band usage of frequencies. There are two possible interference scenarios:

1. MSS Terminal transmitter into Base Station receiver at L-band.
2. MSS Spacecraft transmitter into ATC terminal receiver at S-band.

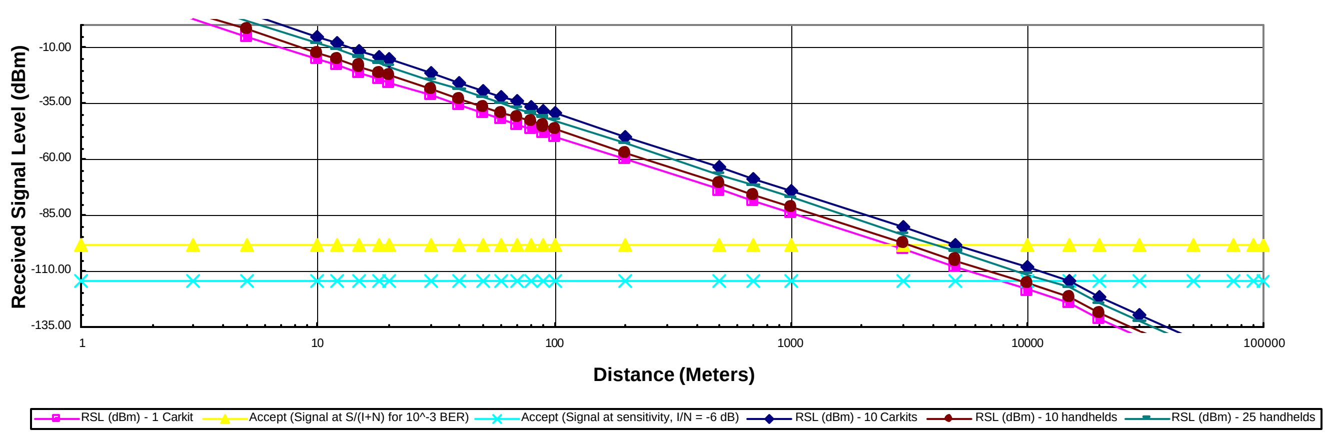
1.3.1 MSS Terminal Transmitter into Base Station Receiver

An MSS terminal transmitter operating on the same frequency as a base station receiver would represent a significant source of interference for the ATC base station. MSS terminals typically operate at much higher transmit powers than terrestrial ATC transmitters. A single MSS handheld terminal is equivalent to 5 ATC terminals, and a vehicular MSS terminal is at higher power than the MSS handheld terminal.

Figure 1.9 illustrates the received interference level for ATC base station receiver from an MSS transmitter as a function of separation distance. The gain of the MSS transmitter is higher above the horizon while a base station receiver is directional below the horizon. This analysis assumes a transmit gain of –3 dB for MSS terminal and receive gain of 17 dBi for the base station receiver. Also, transmit EIRP for a vehicular MSS terminal is 30 dBm and for a handheld MSS terminal is 23 dBm. The interference thresholds are from FCC Final Staff Report for *Spectrum Study of the 2500-2690 MHz Band*.

As shown in Figure 1.9, a single vehicular MSS terminal must be 7 kilometers away from the terrestrial base station before the interference is at an acceptable level, if the signal level is equal to the base station receiver sensitivity for 1% Frame Error Rate (FER). If the base station receiver is operating at S/(I+N) for 10^{-3} BER, then the MSS vehicular unit can be 3 km away from the terrestrial base station. For a 5 km separation distance, 10 vehicular units or 50 handheld units can operate with an acceptable interference level for the base station receiver operating at S/(I+N) for 10^{-3} BER. For this interference case, the received level from the MSS terminal at the terrestrial base station is calculated using the Hata model which is given in ITU-R Recommendation P.529-3. This model is recognized as depicting typical propagation loss for terrestrial cellular systems in dense urban areas.

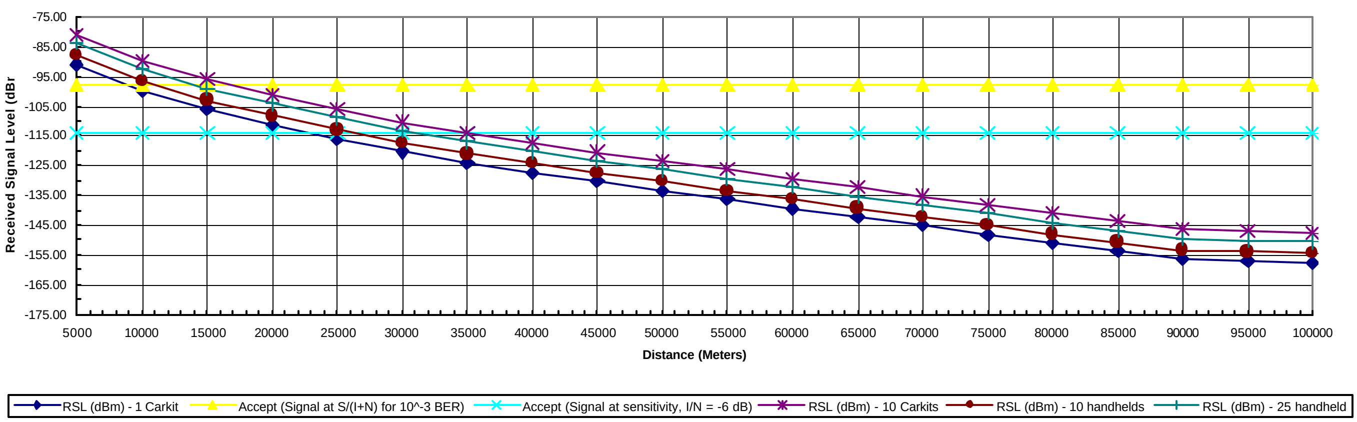
Figure 1.9
Received Signal Level at ATC Base Station Receiver from MSS Terminal transmitter as a Function of Distance from the Base Station (Hata Model)



In the results shown in Figure 1-10, the received level from the MSS terminal at the terrestrial base station is calculated using the Longley Rice propagation from NTIA. This model is used to determine the coverage and attenuation associated with terrestrial cellular systems.

As shown in Figure 1-10, a single vehicular MSS terminal must be 23 kilometers away from the terrestrial base station before the interference is at an acceptable level, if the signal level is equal to the base station receiver sensitivity for 1% FER. If the base station is operating at S/(I+N) for 10^{-3} BER, then the MSS vehicular unit can be 9 km away from the terrestrial base station. For a 16 km separation distance, 10 vehicular units or 50 handheld units can operate with an acceptable interference level for the base station receiver operating at S/(I+N) for 10^{-3} BER. This implies that there will be holes in the coverage beyond the coverage provided by an ATC base station. A typical coverage for an ATC base station is about 5 km. From 5 km to 9 km, an MSS terminal cannot be activated due to the interference into ATC base station.

Figure 1-10
Received Signal Level at ATC Base Station Receiver from MSS Terminal transmitter as a Function of Distance from the Base Station (Longley Rice Model)



1.3.2 <u>Spacecraft Transmitter into ATC Terminal Receiver</u>

The power received from a spacecraft transmitter is not a significant source of interference for an ATC terminal receiver. The receive power levels at an ATC terminal receiver from a spacecraft transmitter are at a much lower level as compared to a base station transmitter. The transmit power of the Spacecraft transmitter is limited by the power flux density incident on the ground. The Power Flux Density (PFD) incident on the ground is constrained to the following mask according to the ITU Radio Regulations:

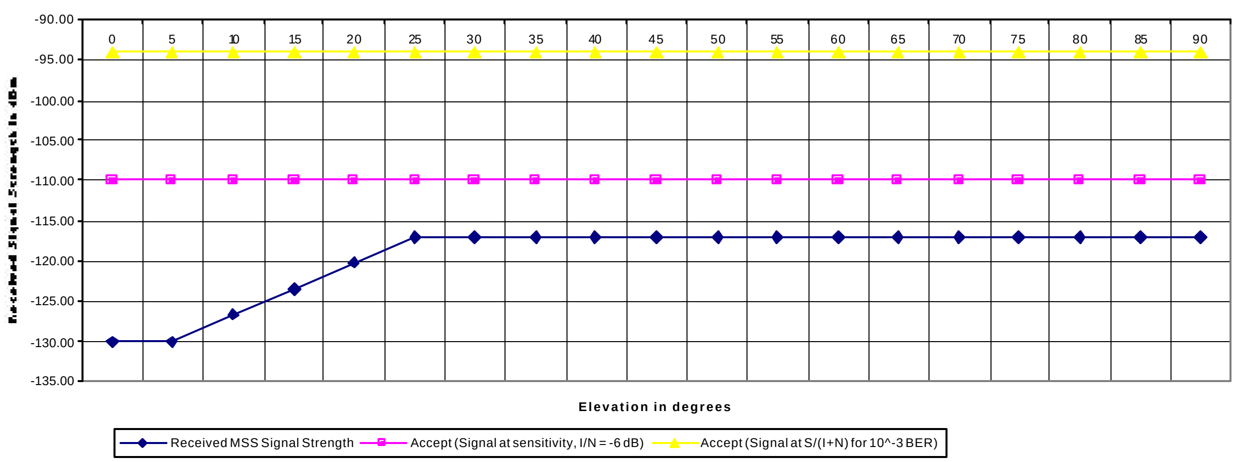
$$pfd_{low} \qquad 0 \le \theta \le 5^{o}$$
$$pfd = pfd_{low} + 0.05(pfd_{hi} - pfd_{low})(\theta - 5) \qquad 5^{o} < \theta \le 25^{o}$$
$$pfd_{hi} \qquad 25^{o} < \theta \le 90^{o}$$

$$\text{where} \quad pfd_{low} = -126 \text{ dBW/m}^2\text{/MHz}$$
$$pfd_{hi} = -113 \text{ dBW/m}^2\text{/MHz}$$

The threshold of acceptable interference is from the FCC Final Staff Report on *Spectrum Study of the 2500-2690 MHz Band*. Figure 1-11 shows the received interference signal at ATC terminal receiver from a spacecraft transmitter as a function of user elevation angle of the ATC terminal. The analysis assumes that the ATC terminal is in clear line of sight of the spacecraft. In the presence of shadowing and fading, the transmit power of the satellite will increase to mitigate the effect of shadowing, but the effective power received by the ATC terminal will remain the same. The receive gain of the ATC terminal is assumed to be 0 dBi.

Figure 1-11

Received Signal Level at ATC Mobile Station Receiver from MSS Satellite Transmitter as a Function of User Elevation



The threshold is 7-23 dB greater than the interference produced by an MSS spacecraft transmitter. This shows that ATC terminals can tolerate the interference from an MSS transmitter.

1.3.3 Summary of interference from MSS into ATC

This analysis has looked at the problem of sharing "forward" frequencies between an MSS system and the ATC. Two interference cases on the effect of MSS transmission into ATC were examined. ATC use of the MSS frequencies in the forward direction results in interference from an MSS spacecraft into the ATC terminal receivers and interference from the MSS handsets into the ATC base station receivers.

The most problematic case of interference is the one caused by an MSS handset into a base station receiver. If the ATC base station is operating at an S/(I+N) for 10^{-3} BER, 10 vehicular units or 50 handhelds can operate at a distance of 5 km from the ATC base station. The separation distance increases with an increase in the number of MSS terminals. The following Table 1-12 shows the separation distance in km for MSS terminals, using Hata and Longley-Rice propagation models. The ATC base station is assumed to be operating at an S/(I+N) for 10^{-3} BER in the following analysis.

Table 1-12

	Separation in km	
MSS terminals	**Hata Model**	**Longley Rice Model**
1 Vehicular units	2.5	9
10 handhelds	3	11
25 handhelds	4	14
10 Vehicular units or 50 handhelds	5	16

A more detailed analysis, outside the scope of this report, is required to calculate the density of the acceptable number of MSS terminals around the ATC base station for an acceptable interference level.

The interference from an MSS transmitter into an ATC terminal is of lesser concern as the interference threshold is 23 dB greater than the received signal which is limited by the pfd mask from the ITU Radio Regulations.

1.4 MSS Interference into IS-95 ATC

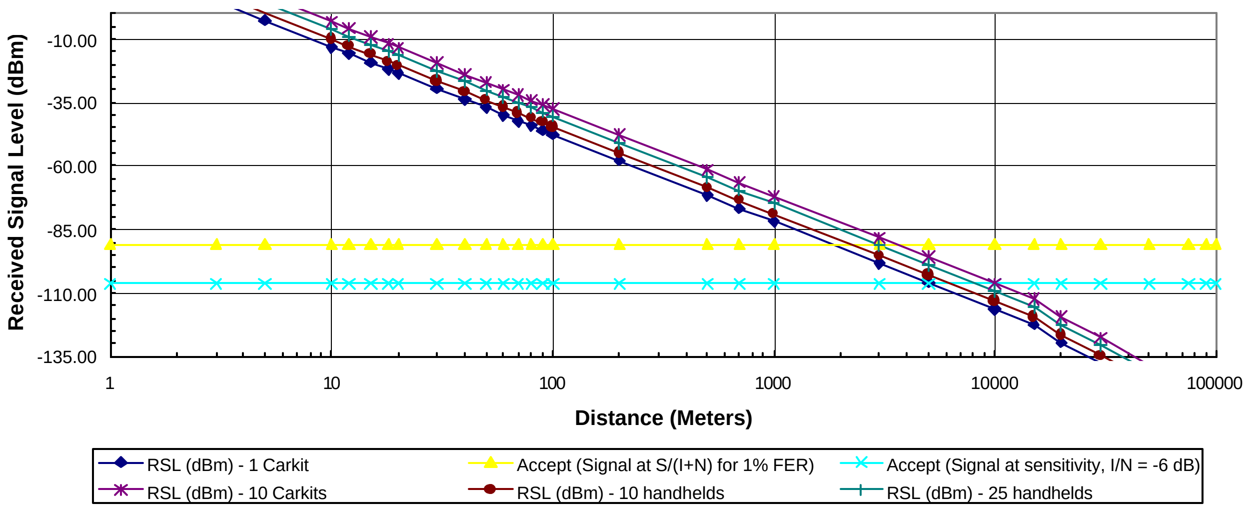
This section considers interference from an MSS system into an ATC that uses IS-95 technology. The characteristics assumed for the terrestrial IS-95 system are shown in the previous Table 1-5. It is worthwhile noting that IS-95 receivers have higher interference thresholds than cdma2000 receivers. Hence, the separation distance for acceptable interference from MSS into ATC are slightly lower than cdma2000 ATC.

1.4.1 MSS Terminal Transmitter into Base Station Receiver

Figure 1-13 illustrates the received interference level at an ATC base station receiver from an MSS transmitter as a function of separation distance. The gain of the MSS transmitter is higher above the horizon while the base station receiver is directional below the horizon. This analysis assumes transmit gain of –3 dB for MSS terminal and receive gain of 19 dBi for base station receiver. The transmit EIRP for a vehicular MSS terminal is 30 dBm and for handheld MSS terminal is 23 dBm. The interference thresholds are calculated based on IS-97A and IS-98A minimum performance standards for terrestrial mobile station and base station respectively.

As shown in Figure 1-13, a single vehicular MSS terminal must be 5 kilometers away from the terrestrial base station before the interference is at an acceptable level, if the signal level is equal to the base station receiver sensitivity for 1% FER. If the base station is operating at a S/(I+N) for a 1% FER, then the MSS vehicular unit can be 2 km away from the terrestrial base station. For a 4 km separation distance, 10 vehicular units or 50 handheld units can operate with an acceptable interference level for the base station receiver operating at a S/(I+N) for a 1% FER. For this interference case, the received level from the MSS terminal at the terrestrial base station is calculated using the Hata model given in ITU-R Recommendation P.529-3. This model is recognized as depicting typical propagation loss for terrestrial cellular systems in dense urban areas.

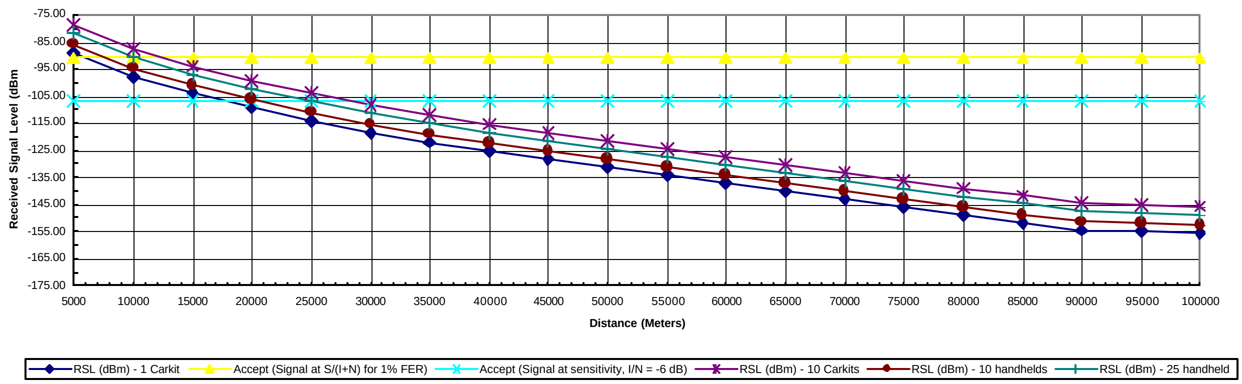
Figure 1-13
Received Signal Level at ATC Base Station Receiver from MSS Terminal transmitter as a Function of Distance from the Base Station (Hata Model)



In the results shown in Figure 1-14, the received level from the MSS terminal at the terrestrial base station is calculated using the Longley-Rice propagation model which is used by FCC in the Part 24 rules. This model is used to determine the coverage and attenuation associated with terrestrial cellular systems.

As shown in Figure 1-14, a single vehicular MSS terminal must be 16 kilometers away from the terrestrial base station before the interference is at an acceptable level, if the signal level is equal to the base station receiver sensitivity for 1% FER. If the base station is operating at a S/(I+N) for a 1% FER, then the MSS vehicular unit can be 6 km away from the terrestrial base station. For a 12 km separation distance, 10 vehicular units or 50 handheld units can operate with an acceptable interference level at the base station receiver operating at a S/(I+N) for a 1% FER. This implies that there will be holes in the coverage beyond the coverage provided by the ATC base station. A typical coverage for an ATC base station is about 5 km. From 5 km to 6 km, an MSS terminal cannot be activated without causing interference into the ATC base station.

Figure 1-14
Received Signal Level at ATC Base Station Receiver from MSS Terminal transmitter as a Function of Distance from the Base Station (Longley Rice Model)



1.4.2 Spacecraft Transmitter into ATC Terminal Receiver

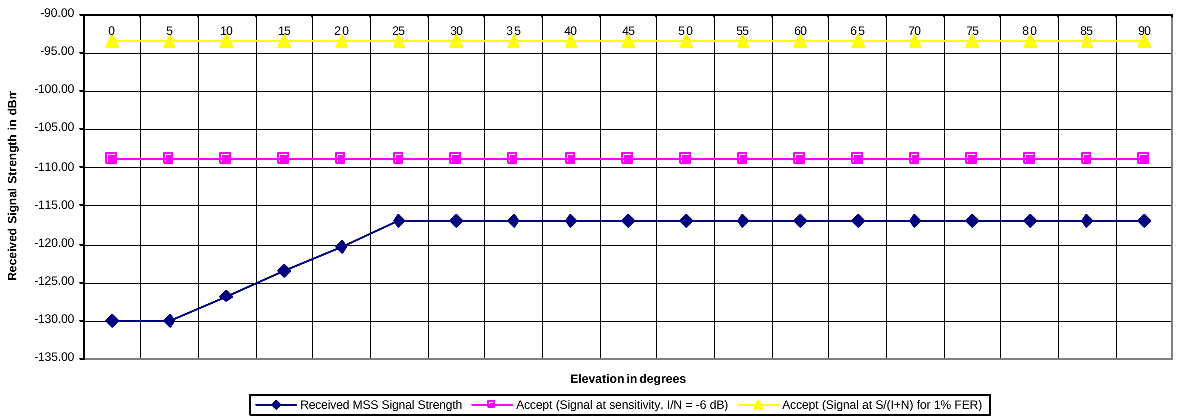
The power received from an MSS spacecraft transmitter is not a significant source of interference for an ATC terminal receiver. The receive power levels at an ATC terminal receiver from a spacecraft transmitter are at a much lower level as compared to a base station transmitter. The transmit power of the spacecraft transmitter is limited by the power flux density incident on the ground. The PFD incident on the ground is constrained to the following mask according to the ITU Radio Regulations:

$$pfd_{low} \qquad 0 \leq \theta \leq 5^{o}$$
$$pfd = pfd_{low} + 0.05(pfd_{hi} - pfd_{low})(\theta - 5) \qquad 5^{o} < \theta \leq 25^{o}$$
$$pfd_{hi} \qquad 25^{o} < \theta \leq 90^{o}$$

where $pfd_{low} = -126$ dBW/m^2/MHz
$pfd_{hi} = -113$ dBW/m^2/MHz

The interference thresholds are calculated based on IS-97A and IS-98A minimum performance standards for terrestrial Mobile stations and base stations, respectively. Figure 1-15 shows the received interference level at the ATC terminal receiver from a spacecraft transmitter as a function of user elevation angle of the ATC terminal. The analysis assumes that the ATC terminal is in clear line of sight of the spacecraft. In the presence of shadowing and fading, the transmit power of the satellite will increase to mitigate the effect of shadowing, but the effective power received by the ATC terminal will remain the same. The receive gain of the ATC terminal is assumed to be 0 dBi.

Figure 1-15
Received Signal Level at ATC Mobile Station Receiver from MSS Satellite Transmitter as a Function of User Elevation



The threshold is 10 to 23.7 dB greater than the interference produced by MSS spacecraft transmitter. This shows that ATC terminals can tolerate the interference from MSS spacecraft transmitters.

1.4.3 Summary of Interference from MSS into ATC Using IS-95

The following Table 1-16 summarizes the results of the interference analysis performed to consider co-frequency usage between MSS and ATC using IS-95 technology. The Table also compares the performance of IS-95 and cdma2000 ATC components. As seen from Table 1-16, IS-95 receivers have higher interference thresholds than cdma2000 receivers, hence, the separation distance for acceptable interference from MSS into ATC is slightly lower than for ATC using cdma2000.

Table 1-16
Summary of Interference Effects from MSS into ATC

	Cdma2000	**IS 95 A**
MSS Terminal Transmitter into ATC Base Station Receiver	Separation distance for 10 vehicular units (Hata Model) is 5 km Separation distance for 10 vehicular units (Longley-Rice Model) is 16 km	Separation distance for 10 vehicular units (Hata Model) is 4 km Separation distance for 10 vehicular units (Longley-Rice Model) is 12 km
MSS Spacecraft Transmitter into ATC Terminal Receiver	Interference threshold is 7 - 23 dB higher than the received signal	Interference threshold is 10 - 23.7 dB higher than the received signal

2.0 Frequency Sharing through Dynamic Frequency Assignment

2.1 Introduction

As shown in Section 1, ATC transmitters can interfere with MSS receivers (both at the MSS terminal and at the satellite). MSS terminal transmissions can interfere with ATC base station receivers. However, through careful frequency and power coordination, ATC service and MSS service can use and re-use the same spectrum.

MSS terminal into ATC base station interference and ATC base station into MSS terminal interference can be mitigated through dynamic frequency control of the MSS frequencies and ATC frequencies as explained below. Basically, ATC receives its own block of spectrum in regions around ATC base stations. The MSS service will not use the same frequency channels that are assigned to the ATC service in the regions near ATC base stations. The frequency assignment is dynamic and managed according to total demand, peaking periods, geographic distribution of terminals, fixed versus mobile usage, etc. As explained in greater detail below, dynamic frequency assignment requires the MSS operator be the ATC operator.

The ATC terminal transmissions are somewhat more complicated to coordinate. The satellite -- regardless of the location of the ATC terminal -– receives the ATC terminal transmissions. On average, the ATC terminal transmission's power level received at the satellite is one-tenth of the power of an MSS terminal's power level. Up to a limit, the ATC terminal "uses" the capacity of the satellite channel even though the terminal is communicating with the ATC base station through CDMA interference sharing as proposed for MSS only users in the Big LEO Negotiated Rulemaking proceeding. So, the MSS and ATC service can use the same return link frequencies in the same region as long as the number of simultaneous ATC terminal transmissions does not degrade the capacity of the MSS service.

Interference mitigation of ATC transmitters into MSS receivers

2.2 ATC transmitter interference into MSS satellite receiver

In the forward band sharing operation, a fairly small number of "uncoordinated" ATC handsets (tens to hundreds) within a Globalstar satellite return link (L-band) beam can produce unacceptable interference to the MSS spacecraft receiver. However, when coordinated (i.e., the MSS operator is also operating the ATC service), the number of ATC handsets can be between 500 and 1000. In this case, an entire Globalstar satellite MSS beam will encounter interference that will render MSS service inoperable at the ATC frequencies. Due to the overlapping beams of the Globalstar constellation, much of the MSS frequency area lost with the victim beam is recovered by neighboring satellites. This is because often the neighboring satellites have beam footprints that interleave with some of the victim beam's area, but do not intersect with an ATC interference source. The difference between the calculations done in Section 1.1.6 and the statements above is that in Section 1.1.6 the ATC and MSS operators are different. Here the operator is the same which allows for proper coordination between the ATC service and the MSS service.

In Figure 2-1 below, a simulation of Globalstar coverage over the Continental U.S. (CONUS) is shown. Seven satellites are observed as having antenna footprints that serve a portion of CONUS. For each satellite, all of the 16 Globalstar return link beams are depicted. ATC service is assumed in ten of the most populous cities in CONUS, plus Washington, DC, and are shown as black dots on the map. Each beam of the seven satellites that serves a portion of CONUS and **does not contain** one of the ATC cities is shaded blue. This area represents all of the area over CONUS that could be served by the entire MSS L-band spectrum assigned to Globalstar. The areas shaded in pink represent regions of beams that contain at least one ATC interference source within them, and are thus regions in which ATC interference renders the frequencies unavailable to MSS service. It is important to note that in order to service the blue regions with full spectrum MSS service, and to properly and optimally serve the MSS users in the pink regions, the satellite operator must have knowledge of the dynamic satellite beam footprints, the ATC frequencies, and the ATC base station loading on a nearly instantaneous basis.

The land area and geometry of the regions affected by ATC interference to the satellite receiver is very dynamic. This can be observed in Figure 2-2, which is a similar analysis of the constellation at a different point in time. However, the time varying geometry is calculable in advance as the function of the Globalstar 48-satellite Walker constellation dynamics and the return link beam definitions. The dynamic nature of regions that can and cannot be served by all MSS frequencies mandates a tight and continuous coordination between the MSS and ATC frequency channels, which must be performed by a single operator to maximize spectrum efficiency and avoid interference.

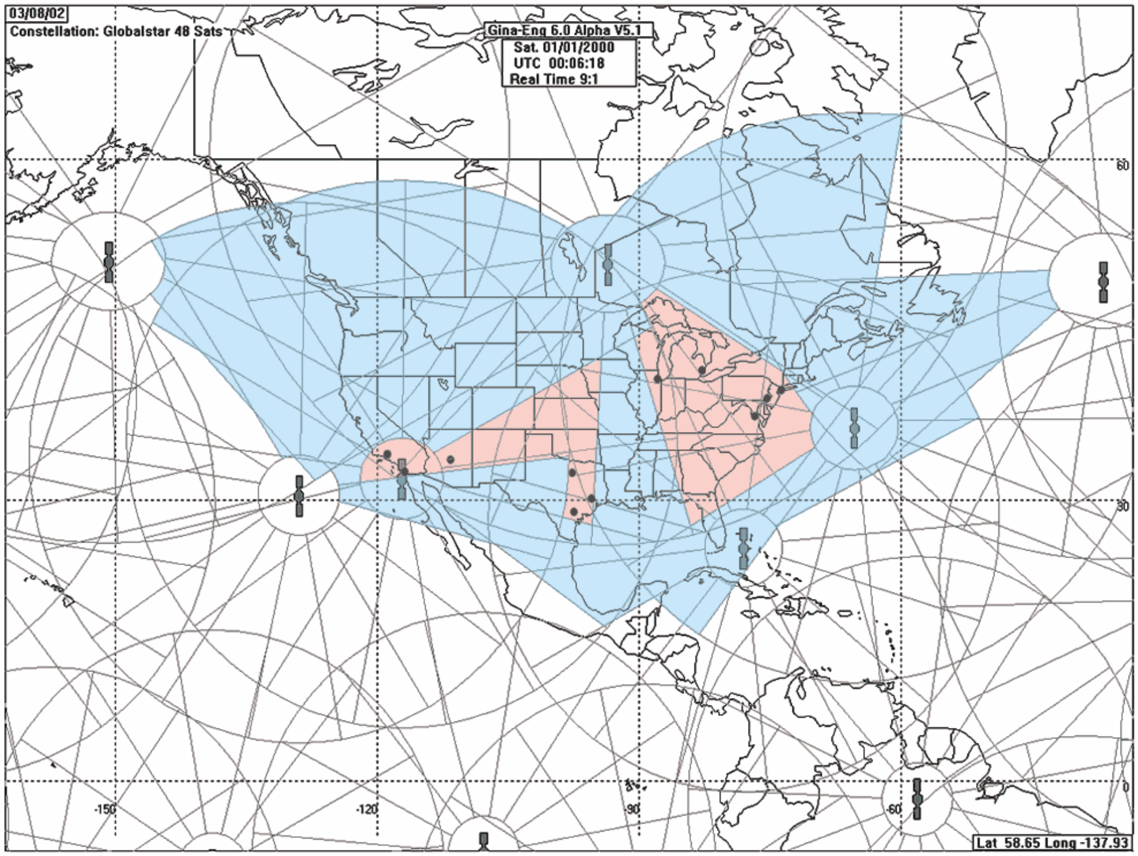


Figure 2-1. Regions of CONUS with Full and Partial MSS Spectrum Available due to ATC Interference – Time 1

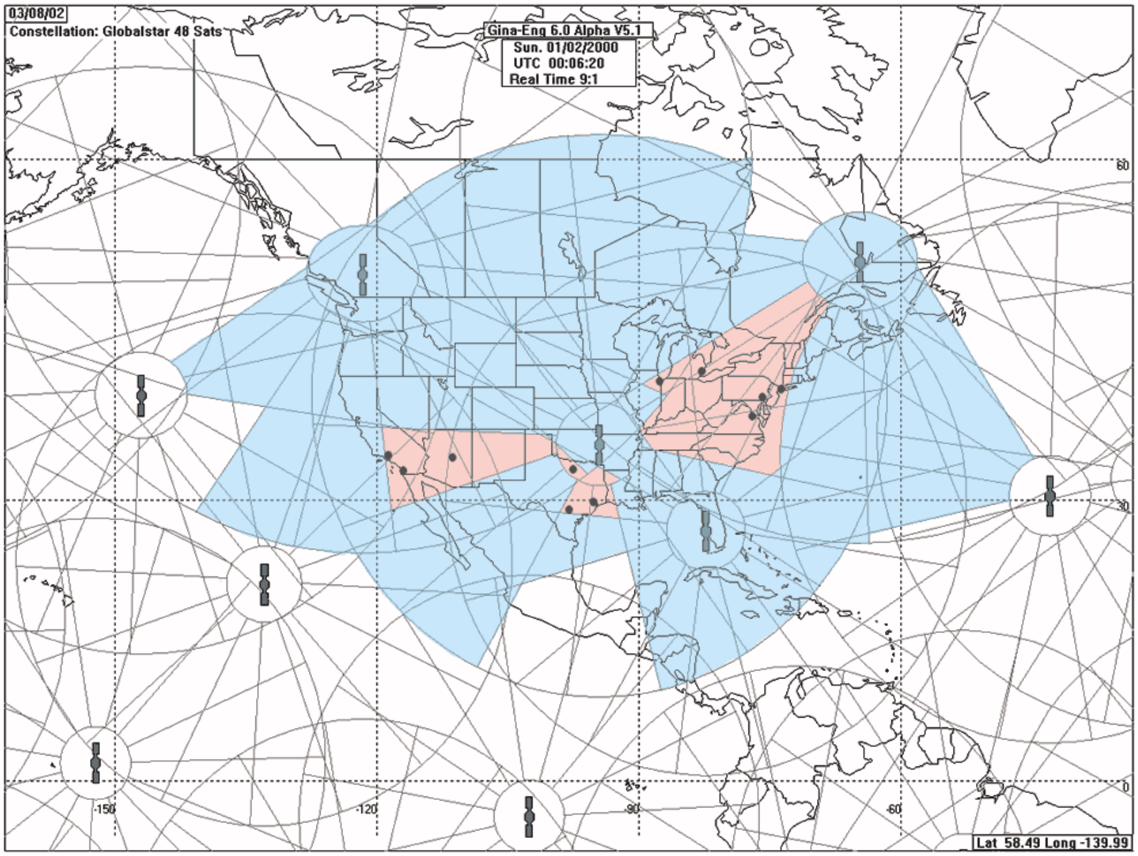


Figure 2-2. Regions of CONUS with Full and Partial MSS Spectrum Available due to ATC Interference – Time 2

2.3 Enhancement to spectrum efficiency via dynamic ATC frequency assignments

If the MSS-ATC operator can dynamically assign multiple ATC frequencies in the MSS band, additional rural areas can have access to the full MSS spectrum available. Existing algorithms allow the MSS operator to exploit the beam and city geometry to maximize spectrum efficiency. As an example, it can be shown that there are always times where two beams from two different satellites overlap in a rural region, while the extremities of the two beams serve two separate, individual ATC cities or clusters of ATC cities. In these cases, the service provider could select distinct ATC frequencies for the two beams. In the regions where the beams overlap, the ATC frequency not found in one beam would be found in the other beam; thus this rural region reclaims the full MSS bandwidth. The dynamic nature of this algorithm adds complexity, as the MSS-ATC provider must dynamically alter ATC frequencies among the ATC cities in an optimal manner. This task could not be accomplished unless the MSS and ATC operator are one and the same. Figure 2-3 represents the same constellation position as shown previously in Figure 2-1. In this case, green and purple dots represent ATC city locations in which separate ATC frequencies are deployed, while the black dot cities represent either set of frequencies. The yellow regions represent areas restored to full MSS spectrum availability using this algorithm. Figure 2-4 shows the constellation six minutes later, illustrating the rate at which the frequency assignments must be computed and imposed.

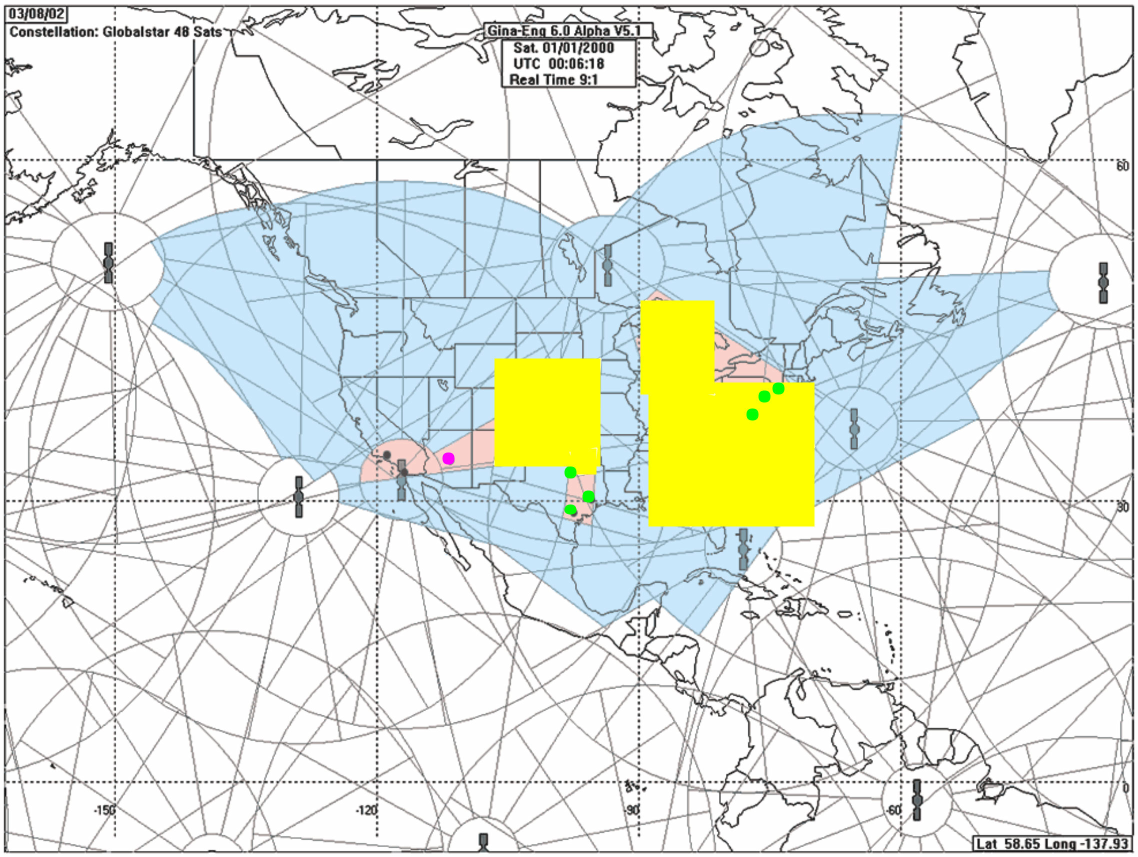


Figure 2-3. Regions of CONUS with full MSS spectrum recovered with frequency assignment algorithm – Time 1

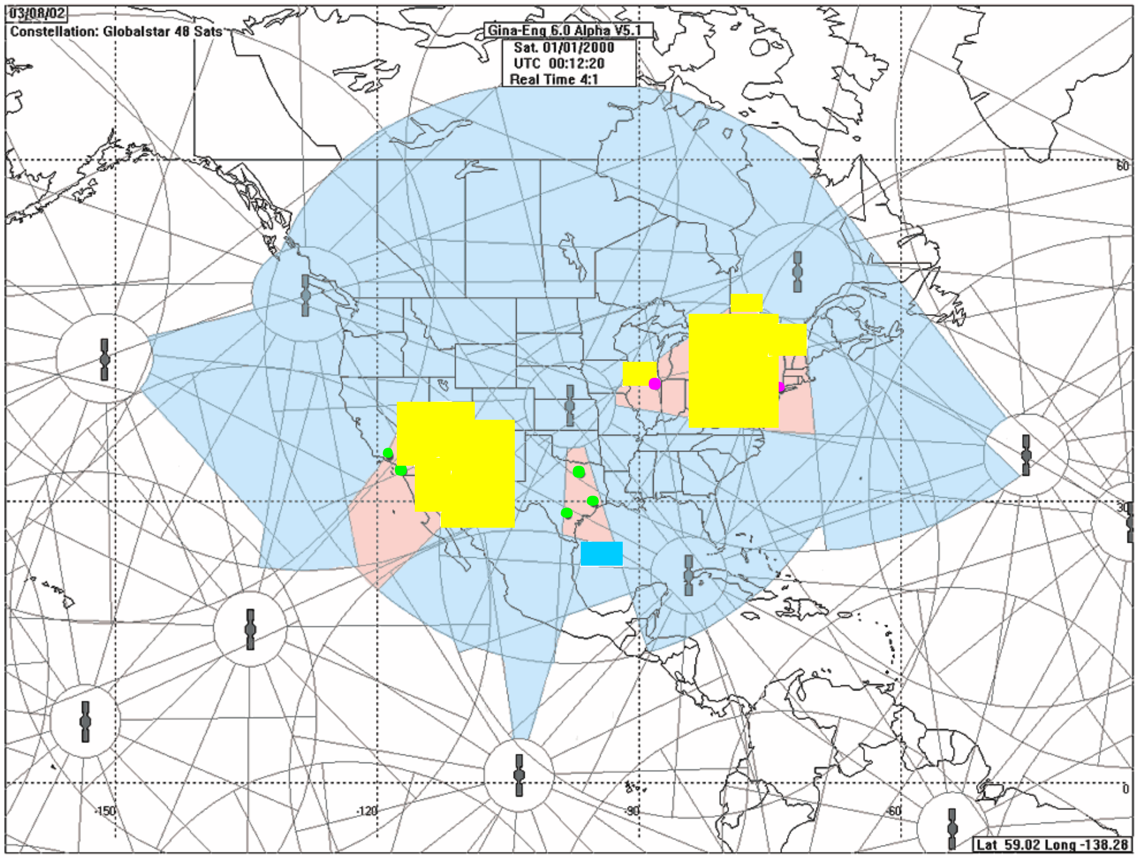


Figure 2-4 Regions of CONUS with full MSS spectrum recovered with frequency assignment algorithm – Time 2

2.4 ATC transmitter interference into a MSS terminal receiver

In the forward band sharing mode of operation, interference from an ATC base station to an MSS terminal receiver is significant for separations of less than 5 km for cdma2000 and less than 7 km for IS-95A. To mitigate this interference in regions near the borders of ATC and MSS service, knowledge of the MSS terminal receiver location and knowledge of the locations of all ATC base stations would allow the system to coordinate which frequencies or which system (satellite or terrestrial) the terminal should optimally be using. The Globalstar system currently uses position determination during the MSS terminal registration process. This could be augmented with terrestrial position location information. In the event an MSS terminal was attempting MSS service within an ATC base station's serving area, the terminal could be directed to obtain service terrestrially, or alternatively to use non-ATC frequencies for MSS. Note that the size of the base station interference zone to the MSS terminal would be dynamic depending upon ATC loading, which would be known by the operator of an integrated MSS-ATC system. Logic within the terminal would allow it to transition back to the MSS service should the ATC service not be found.

Interference mitigation of MSS transmitters to ATC receivers

2.5 MSS satellite transmitter interference into an ATC terminal receiver

In the forward band sharing mode of operation, the MSS satellite operates on the same frequencies as the ATC terminal receiver, and is thus a potential source of interference. As shown in Section 1.3.2, the level of this interference is significantly lower than the interference threshold for the ATC receiver, even assuming a clear line of sight from the ATC terminal to the MSS satellite. This analysis shows that a mitigating strategy is not required.

2.6 MSS terminal transmitter interference into an ATC base station receiver

In the forward band sharing mode of operation, the MSS terminal transmits in the ATC base station receive frequencies. An analysis of this case is detailed in Section 1.3.1, where it was shown that the interference threshold to the base station is reached when 50 MSS terminals operate at a distance of 5 km from the ATC receiver. Reciprocally, the ATC base station transmitter signal is received as interference to the MSS terminal receiver. The use of position location would preclude the use of ATC and MSS terminals in such proximity, thus mitigating MSS interference to the ATC receiver. An integrated MSS-ATC system could make use of the numbers and locations of all MSS users in a geographic region in assessing both frequency allocations and type of service to initiate.

3.0 Interference Considerations in the Coordination of Frequency Sharing with the Ancillary Terrestrial Component of Mobile Satellite Service Systems into Other CDMA MSS Operators

This section considers the coordination between CDMA MSS-ATC operators with whom Globalstar is spectrum sharing.

3.1 MSS to MSS Service Link Coordination

Globalstar uses the bands 1610-1621.35 MHz and 2483.5-2500 MHz for its service uplink and downlink, respectively. These bands are also planned to be used by other CDMA MSS systems such as Constellation. To ensure equitable utilization of these bands by all MSS systems employing CDMA, intersystem coordination is necessary.

Recommendation ITU-R M.1186, *Technical Considerations for the Coordination Between Mobile Satellite Service (MSS) Networks Utilizing Code Division Multiple Access (CDMA) and other Spread Spectrum Techniques in the 1-3 GHz Band*, recommends seven parameters to be considered for the coordination of CDMA MSS systems:

1) Downlink spectral power flux density (pfd),
2) Aggregate uplink EIRP spectral density over a specified geographical area,
3) Polarization,
4) Frequency reuse approach,
5) Code structure and associated cross-correlation properties,
6) Antenna beam patterns, and
7) Signal burst structure (if applicable).

Globalstar has used these parameters in the past to coordinate with the other Big LEO systems, and will continue to use these parameters in the future. The first two are the most important ones and require detailed coordination. Successful coordination between CDMA MSS operators can be achieved using these seven parameters. When the MSS operators offer ATC service as well, these are still the parameters to be used for coordination. In fact, all the parameters and the coordination of all the parameters remain the same except one, the aggregate uplink EIRP spectral density over a specified geographic area. This parameter will be discussed below.

When Above 1 GHz MSS operators using CDMA offer ATC service in the same band, they will continue to share the entire allocated band for MSS service. A coordinated portion of the band will be allocated for MSS only (no ATC service allowed by any operator). This is to ensure that MSS service can be provided anywhere and everywhere.

If there were no MSS-only portion of the band and a certain operator did not roll out ATC in a particular region and all the other operators did roll out ATC, it might not be possible for the MSS-only operator to offer MSS in that ATC region due to the interference scenarios described above.

3.2 ATC Service Coordination with Other ATC Service

For multiple MSS operators to offer ATC service, the ATC frequencies have to be coordinated per geographic region. The near-far problem is too large in terrestrial service for providers to use the same frequencies in the same geography.

Therefore, MSS-ATC operators have to coordinate ATC service by segmenting the spectrum per geographic region. Each operator will have dedicated ATC spectrum in a given region. The MSS service from all operators will re-use the spectrum in non-ATC regions.

3.3 ATC Service Coordination with Other MSS Service

To coordinate ATC service between two MSS operators, the operators will have to coordinate, specifically, which frequencies ATC is using in which geographic region.

As shown in Section 1, the ATC base station transmissions interfere with the MSS terminal receiver on the same frequency when the MSS terminal is relatively close to the ATC base station. Also, as shown in Section 1, the MSS satellite transmissions do not interfere with the ATC terminal. Therefore, an MSS operator can offer MSS service in a region where another MSS operator has rolled out ATC service as long as the MSS operator uses different frequencies than the ATC service is using. If the operators have coordinated ATC frequencies, the MSS operator will be able to offer MSS service in an area in which another MSS operator has rolled out ATC service.

In the forward direction, in those areas where none of the MSS-ATC providers have rolled out ATC service, the complete band is shared for MSS service. The MSS operators do not concern themselves with forward downlink beams using the same frequencies that another ATC operator uses in an overlapping area because, as stated above, the MSS satellite does not interfere with the ATC terminal receiver.

Return link frequency coordination is required as well. As shown in Section 1, the MSS terminal transmissions interfere with the ATC base station receiver when relatively close to the base station and the ATC terminal transmissions interferes with the MSS satellite receiver whenever the MSS satellite has a beam in view of the ATC terminal.

To mitigate the MSS terminal's interference into another operator's ATC base station, an MSS operator can offer MSS service in an area where another MSS operator has rolled out ATC service as long as the MSS operator uses different frequencies than the ATC service is using. If the other operator's ATC frequencies are known in advance (which coordination would require), the MSS operator will be able to offer MSS service in an area in which another MSS operator has rolled out ATC service. In this way, the MSS terminal transmissions will not interfere with the ATC base station receiver.

To mitigate the ATC terminal's interference into another operator's satellite receiver, coordination is required as explained in Section 2. This means that the full MSS spectrum can be used for MSS services in those regions where beams overlap; the ATC frequencies from either operator not found in one beam would be found in the other beam. There will be cases where the ATC frequencies of the same MSS operator will be able to be used but not the ATC frequencies used by another MSS-ATC operator (and vice versa).

In regions where the satellite beams view many ATC terminals and there is no beam overlap, only the non-ATC frequencies can be used for MSS.

To coordinate the interference at the MSS satellite receiver, the aggregate uplink EIRP spectral density over a specified geographic area will be used. This EIRP spectral density includes the EIRP from ATC terminals as well as MSS terminals. In those areas where no ATC service is offered, the MSS operators will coordinate a value (presumably the same value for each operator) that is acceptable for MSS operations. In those regions where an MSS-ATC operator offers ATC service, the aggregate uplink EIRP spectral density for that operator will be higher for the spectrum in which ATC service exists. In those regions where ATC service is offered by another MSS-ATC operator, the aggregate uplink EIRP spectral density for the MSS operator will be lower for the spectrum in which other operator’s ATC service exists. Figure 3.1 depicts the EIRP spectral density limits over a geographic area.

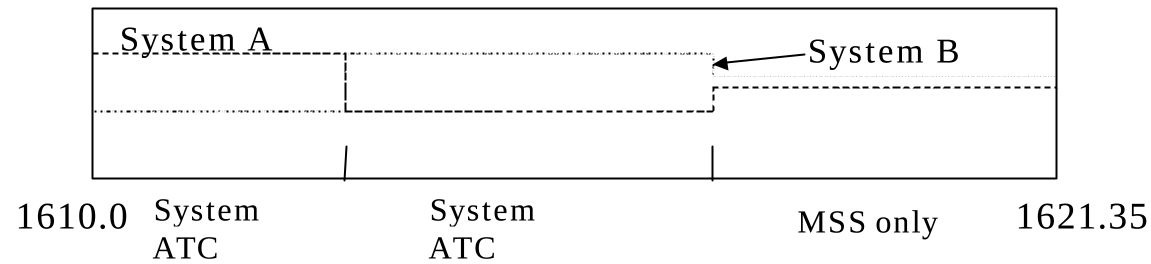


Figure 3-1. **<u>Example EIRP Density to Coordinate MSS and ATC Operations</u>**

3.4 <u>Summary and Conclusions</u>

At least two CDMA MSS-ATC operators can coordinate MSS and ATC services in the L-band and S-band Big LEO spectrum. The same considerations would apply if two or more CDMA MSS-ATC operators were to share spectrum in the 2 GHz MSS band. The MSS service is coordinated as outlined in Recommendation ITU-R M.1186, *Technical Considerations for the Coordination Between Mobile Satellite Service (MSS) Networks Utilizing Code Division Multiple Access (CDMA) and other Spread Spectrum Techniques in the 1-3 GHz Band*.

The ATC and MSS services are coordinated by band segmenting and by setting appropriate aggregate uplink EIRP spectral density limits over a specified geographical area. The EIRP spectral density limits include the EIRP from ATC terminals as well as MSS terminals. Each MSS-ATC operator has to have complete information of the ATC regions and frequencies used by the other MSS-ATC operators.

4.0 Interference from ATC into Other Services

This section explains how an Above 1 GHz MSS system can manage interference from ATC terminals into other services. The other services are Radio Astronomy (in-band), Iridium (out-of-band), GPS (out-of-band), and GLONASS (out-of-band). There are three possible interference scenarios:

ATC Terminal transmitter into Radio Astronomy receiver (in-band)

ATC Terminal transmitter into Iridium receiver (out-of-band)

ATV Terminal transmitter into GPS/GLONASS receivers (out-of-band)

4.1 ATC Terminal Transmitter into Radio Astronomy Receivers

The CDMA MSS uplink spectrum overlaps with the Radio Astronomy Service (RAS) spectrum. The FCC adopted rules for sharing with RAS (47 C.F.R. § 25.213(a)), and, recently, Globalstar and the National Science Foundation (NSF), representing the interests of the U.S. radio astronomers, signed a technical operational coordination agreement covering the 1610.6-1613.8 MHz segment of L-band (the overlapping spectrum). Spectral density limits and radio exclusion zones are used to limit Globalstar terminal transmissions into RAS. The radio exclusion zone size is set according to either the user terminal EIRP for in-band channels or the user terminal out-of-band emissions for channels that are above the RAS.

Globalstar’s ATC terminals will be designed with the same out-of-band emission specifications as the current Globalstar MSS terminals. The exclusion zones for ATC will be implemented by the placement of ATC base stations. ATC base stations with in-band channel assignments will be placed at the appropriate distance from Radio Astronomy sites as will ATC base stations (albeit it closer to the RAS sites) with channel assignments that are not in-band to the Radio Astronomy spectrum.

In short, to protect Radio Astronomy spectrum from interference, Globalstar will use the same coordination methodologies for its ATC service as Globalstar does for MSS.

4.2 ATC Terminal Transmitter into Iridium Receiver

Globalstar and Iridium have coordinated the out-of-band emissions between the systems at L-band to limit the out-of-band emissions from Globalstar terminals into Iridium's spectrum to coordinated values. Globalstar ATC terminals will be specified with the same requirements for out-of-band emission as the Globalstar MSS terminals. Therefore, the Globalstar ATC terminals' interference into Iridium will be limited to the current coordinated values.

4.3 ATC Terminal Transmitter into GPS/GLONASS Receivers

In the NPRM in IB Docket 99-67,[1] the FCC has proposed technical rules to limit out-of-band emissions for MSS terminals to, among other things, protect Aeronautical Radionavigation Satellite (GPS/GLONASS). These proposed rules are similar in almost all respects to ITU-R Recommendation M.1343. Globalstar supports the Commission's proposed limits, and Globalstar's MSS terminals have been tested and type-approved to meet these limits. Globalstar's ATC terminals will be specified with the same requirements for out-of-band emissions as Globalstar's MSS terminals. Accordingly, the ATC terminals' interference into GPS/GLONASS will be limited to the current proposed values.

4.4 1.6 GHz Band Services Summary and Conclusions

Globalstar will use the same coordination techniques and methods for its ATC service as Globalstar does for its MSS service. Interference from ATC to other services will be held to the same limits as interference from Globalstar MSS. The Globalstar ATC terminal specifications will have the same requirements for out-of-band emissions that the Globalstar MSS terminal already have. ATC base stations will be placed in coordination with other services so that interference is limited to acceptable levels.

4.5 Interference into Adjacent Band ITFS and MMDS

This section studies the potential for interference due to ATC base station transmitters into ITFS/MMDS services operating in 2500-2690 MHz band. ATC base station transmitters will be operating in S-band from 2483.5 to 2500 MHz band, using 1.25 MHz channels. The highest frequency (Channel 13) that ATC

[1] *Amendment of Parts 2 and 25 to Implement Global Mobile Personal Communications by Satellite (GMPCS) Memorandum of Understanding and Arrangements*, 14 FCC Rcd 5871 (1999).

base station will operate will be 2498.535-2499.765 MHz with a guard band of 0.235 MHz. The FCC staff's report, *Spectrum Study in 2500-2690 MHz Band*, includes findings of potential 3G base station interference into ITFS/MMDS receivers and the guard band required to mitigate such interference. The values for interference protection are shown in the following Tables 4-1 and 4-2. Globalstar's ATC base stations would be designed to conform with these values.

Table 4-1: Planning Factors for Guard Band to Protect ITFS/MDS Response Station Receivers from ATC Transmitters

Quantity	Value	Comment
Mid-frequency of 2500-2690 Band	2595 MHz	Arithmetic mean for estimation of antenna aperture areas
Gain of Receiving Antennas of Response Stations	Factor of 100, or 20 dBi	See §21.902(f)(3) and §74.937(a).
Antenna Aperture of Receiving Systems	0.106 m^2	$(\text{wavelength})^2$ * (gain) / (4π)
Desired Signal Strength for Response Stations on Periphery of Protected Service Area	-83 dBW for 6 MHz channels	See §21.902(f)(6)(iii).
Desired Power Flux Density for Response Station on Periphery of Protected Service Area	-73 dBW/m^2 for 6 MHz channels	Value calculated from that given in §21.902(f)(6)(iii) and antenna aperture of 0.106 m^2.
Desired-to-undesired Signal Ratio (D/U) for Adjacent-channel Interference	0 dB	See §21.902(f)(6)(iv) and §74.739(d)(3)(v).
Power Flux Density of Adjacent –channel Undesired Signals Causing Harmful Interference	-73 dBW/m^2 for 6 MHz channels	D/U ratio of 0 dB with no guard band
Response Station Receiver (TV) Interference Rejection Characteristic attainable by Greater Frequency Separation	40 dB per MHz	FCC Laboratory measurements of television receivers
Power of 3G Transmitters	Maximum of 1.64 kW EIRP	Base station power dominates all guard band considerations because mobile power is less.

Table 4-2: Planning Factors for Guard Band to Protect ITFS/MDS Hub Receivers from ATC Transmitters

Quantity	Value	Comment
Transmitter Power of Response Stations (source of ITFS/MDS desired signals)	Maximum 18 dBW EIRP for 125 kHz channels	See §21.909(g)(3). 18 dBW is approximately 63 W.
Desired Power Flux Density at ITFS/MDS Hub	-88 dBW/m^2 for 125 kHz channels	63 watts EIRP from response station transmitter 35 miles away
Maximum Undesired Adjacent-channel Power Flux Density at ITFS/MDS Hub	**-88 dBW/m^2 per 125 kHz**	0 dB D/U ratio assumed
Interference Immunity Attainable by Greater Frequency Separation	40 dB per MHz	Assumed on basis of typical spectrum emission mask requirements for 3G transmitters and adjacent-channel rejection capability of hub receiver.
Power of 3G Transmitters	Maximum of 1.64 kW EIRP	Base station power dominates all guard band considerations because mobile power is less.

4.6 2.5 GHz Band Services Summary and Conclusions

The FCC staff's report describes findings for 3G base station transmitters with 27 dBW (500 watt) EIRP. These findings were applied to the ATC base station assumed to be 3G (i.e., cdma2000). The separation distance and the guard band for ATC base stations with 10 dBW EIRP were calculated using the same formula. These results are shown in Table 4-3. As seen in Table 4-3, a 2 MHz guard band is sufficient to reduce the level of interference from an ATC base station transmitter to an acceptable level. Hence, an ATC base station can operate in Channels 1-11. For an ATC base station with transmit EIRP 10 dBW operating on Channel 13 with a guard band of 0.235 MHz, a separation distance of 30 km is required. For an ATC base station operating on Channel 12 with an additional 1.23 MHz guard band, a separation distance of 0.1 km is required. An ATC base station with 27 dBW EIRP cannot operate in Channel 13, but can operate in Channel 12 with a separation distance of 0.74 km. Standard Fixed Service coordination procedures may be used by MSS-ATC and ITFS/MMDS to avoid interference.

Table 4-3 : Calculation of Separation Distances, ATC Base Station to ITFS/MDS

Guard Band Analysis Based on Interference Power in Adjacent or Nearby Channels

The required separation for adjacent channels (zero-width guard band) is the distance needed to reduce the ATC EIRP to an acceptable power flux density at the ITFS/MDS receiver. The latter is determined as the amount which would be received in the ITFS/MDS adjacent channel at a level equal to the desired signal (D/U = 0 dB).

The required separation for guard bands of greater width is determined by allowing 40 dB reduction of interfering power per MHz of guard band.

ATC System Parameters			ITFS/MDS System Parameters		Required Separation (km)						
Modulation Type	**EIRP (dBW)**	Bandwidth (kHz)	Protected Receiver	Bandwidth (kHz)	Desired Signal Power Density (dBW/m2)	Bandwidth Factor (dB)	Maximum Acceptable 3G Power Flux Density (dBW/m2)	Adjacent Channels (No Guard Band)	Guard 0.5	Band (MHz) 1	Width 2
CDMA	**27**	1250	Hub	125	-90	10	-100	161	16.1	1.6	0.0
CDMA	**27**	3750		125	-90	15	-105	161	16.1	1.6	0.0
W-CDMA	**27**	5000		125	-90	16	-106	161	16.1	1.6	0.0
TDMA	**27**	30		125	-90	-6	-84	100	10.0	1.0	0.0
TDMA	**27**	200		125	-90	2	-92	161	16.1	1.6	0.0
CDMA	**27**	1250	Response	6000	-67	-7	-60	6.3	0.6	0.1	0.0
CDMA	**27**	3750	Station	6000	-67	-2	-65	11.2	1.1	0.1	0.0
W-CDMA	**27**	5000		6000	-67	-1	-66	12.6	1.3	0.1	0.0
TDMA	**27**	30		6000	-67	-23	-44	1.0	0.1	0.0	0.0
TDMA	**27**	200		6000	-67	-15	-52	2.5	0.3	0.0	0.0
CDMA	**10**	1250	Hub	125	-90	10	-100	89	8.9	0.9	0.0

ATC System Parameters			ITFS/MDS System Parameters		Required Separation (km)						
Modulation Type	**EIRP (dBW)**	Bandwidth (kHz)	Protected Receiver	Bandwidth (kHz)	Desired Signal Power Density (dBW/m2)	Bandwidth Factor (dB)	Maximum Acceptable 3G Power Flux Density (dBW/m2)	Adjacent Channels (No Guard Band)	Guard 0.5	Band (MHz) 1	Width 2
CDMA	**10**	3750		125	-90	15	-105	159	15.9	1.6	0.0
W-CDMA	**10**	5000		125	-90	16	-106	161	16.1	1.6	0.0
TDMA	**10**	30		125	-90	-6	-84	14	1.4	0.1	0.0
TDMA	**10**	200		125	-90	2	-92	36	3.6	0.4	0.0
CDMA	**10**	1250	Response	6000	-67	-7	-60	0.9	0.1	0.0	0.0
CDMA	**10**	3750	Station	6000	-67	-2	-65	1.6	0.2	0.0	0.0
W-CDMA	**10**	5000		6000	-67	-1	-66	1.8	0.2	0.0	0.0
TDMA	**10**	30		6000	-67	-23	-44	0.1	0.0	0.0	0.0
TDMA	**10**	200		6000	-67	-15	-52	0.4	0.0	0.0	0.0

5.0 Applicability of Part 24 Rules to ATC

Part 24 of the FCC Rules contains requirements and restrictions for terrestrial Personal Communications Services (PCS). Much of the material in Part 24 deals with service areas, frequency band segmentation, competitive bidding for the spectrum to be used for these services and license processing rules. In addition, a significant amount of material deals with the coordination of PCS operation with Fixed Service operation and, where necessary, the relocation of Fixed Service facilities. These aspects of Part 24 would not have a bearing on the Ancillary Terrestrial Component of MSS (ATC). What may be germane to ATC are the technical standards contained in Part 24. These include frequency of operation, power limits and permitted antenna heights, out-of-band emission limits, type acceptance requirements, antenna marking requirements, radiation hazard requirements and compliance with the Communications Assistance for Law Enforcement Act (CALEA).

ATC is proposed to be used in all of the existing MSS allocations. In the case of Globalstar these bands are 1610-1621.35 MHz and 2483.5-2500 MHz for the current system and portions of the 1990-2025 MHz and 2165-2200 MHz bands for the planned 2 GHz MSS system.

ATC power and antenna height limits would have to be consistent with the efficient sharing of frequencies between ATC and the satellite component of MSS. Study would be required to determine these limits.

Globalstar terminals are currently required to meet the limits given in Globalstar USA's current blanket handset license (E970381) which are similar to those found in ITU-R Recommendation M.1343. It is believed that these limits are sufficient to insure that ATC handsets do not cause interference to adjacent services. The out-of-band emission requirements for base stations would be derived based on the interference requirements of adjacent services.

Existing Globalstar handsets have been type accepted and this procedure would also be a requirement for ATC handsets and base stations. Similarly, the existing Globalstar handsets meet radiation hazard requirements and these requirements would also have to be met by ATC handsets and base stations. ATC base stations antenna marking requirements would be the same as those for PCS base station antennas.

Globalstar currently complies with CALEA requirements at its existing gateway terminals. It is reasonable to expect that current and future CALEA requirements would also be met by the ATC system.

Conclusions

These technical comments have examined whether or not the operations of mobile satellite services (MSS) in the "Big LEO" MSS bands can be "severed" from terrestrial operations in each band. It has been shown that it is not possible to "sever" satellite and terrestrial operations. Unacceptable levels of interference would occur between the two components thereby reducing the efficiency of the spectrum usage.

Coordination of frequency usage by the MSS entity would allow the effective sharing of the frequencies between the ATC and MSS on a dynamic basis thus enhancing flexibility and spectrum efficiency. In order to prevent unacceptable interference and maintain flexibility, it is critical that coordination of the use of frequencies in an ATC regime be carried out by only one entity. In light of the dynamic frequency control required by MSS systems, it is most appropriate for the MSS operator to coordinate the usage of the frequencies used for ATC. Integrated MSS-ATC operations would not cause any increase in interference to other services.

Engineering Certification

I hereby certify under penalty of perjury that I am the technically qualified person responsible for preparation of the engineering information contained in the foregoing "Response to FCC Public Notice DA 02-554"; that I am familiar with the information contained therein; and that such information is true and correct to the best of my knowledge and belief.

Signed this 22nd day of March 2002.

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